filter-press from the solution containing the sodium ortho- and parasulphonates.

$$\left(C_6H_4\begin{cases}CH_3\\SO_3\end{cases}\right)_2Ca + Na_2CO_3 = CaCO_3 + 2C_6H_4\begin{cases}CH_3\\SO_3.ONa.\end{cases}$$

The sodium toluene sulphonates

STEP IV.—The solution of the sodium salts from III. is evaporated either in an open or in a vacuum-pan so far that a portion taken out will solidify on cooling. The contents of the pan are then run into moulds of wood or iron, and allowed to cool and solidify. The lumps are at length taken from the moulds, broken up small, and dried in a drying-room, and subsequently in a drying apparatus heated with steam, until quite desiccated.

STEP V.—The sodium sulphonate salts are now converted into their corresponding sulphonic chlorides. This is effected as follows:—The dried sulphonates are thoroughly mixed with phosphorus trichloride, itself as dry as possible. The mixture is then placed in lead-lined iron vessels, and a current of chlorine is passed over the mixture till the reaction is ended. The temperature generated by the reaction must be properly regulated by cooling the apparatus with water. The phosphorus oxychloride resulting from the decomposition is driven off, collected, and utilised for developing chlorine from bleaching powder for the chlorinating process, phosphate of lime being precipitated, which can be used in manures. For this purpose the oxychloride is treated with water, and the mixture, now containing hydrochloric and phosphoric acids, is brought into contact with the chloride of lime.

The reaction by which the ortho- and para-toluene sulphonic chlorides are produced is indicated by the following equation:—

$$C_6H_4\begin{cases}CH_3\\SO_3Na\end{cases} + (PCl_3 + 2Cl) =$$

$$C_6H_4\begin{cases}CH_3\\SO_2Cl\end{cases} + POCl_3 + NaCl.$$

Toluene sulphonic chlorides

The two sulphonic chlorides remaining in the apparatus are allowed to cool slowly, when the solid one (the para compound) is deposited in large crystals, so that the liquid one can be easily removed by the aid of a centrifugal machine. The crystalline residue is freed from all the liquid sulphonic chloride by washing with cold water. Only the liquid orthotoluene sulphonic chloride is capable of yielding saccharine, and the liquid product above separated is cooled with ice to crystallise out the last traces of the crystalline compound. The solid parasulphonic chloride obtained as by-product, is decomposed into toluene, hydrochloric, and sulphurous acids by mixing it with carbon, moistening the mixture, and subjecting it under pressure to the action of superheated steam. The total change proceeds in two stages:—

$$1.\ C_6H_4\begin{cases}CH_3\\SO_2Cl\end{cases} + H_2O = C_6H_4\begin{cases}CH_3\\SO_2OH\end{cases} + HCl.$$

$$2.\ 2\left(C_6H_4\begin{cases}CH_3\\SO_2OH\end{cases}\right) + C = 2(C_6H_5.CH_3) + CO_2 + SO_2.$$

The toluene is then used again in Step I., and the hydrochloric and sulphurous acids in Step VII.

STEP VI.—The liquid orthotoluene sulphonic chloride is now converted into the orthotoluene sulphonic amide by treating the former with solid ammonium carbonate in the required proportions, and subjecting the resulting thick pulpy mixture to the action of steam. Carbonic acid is set free, and a mixture of orthotoluene sulphonic amide and ammonium chloride remains.

$$C_6H_4\begin{cases}CH_3\\SO_2Cl\end{cases} + (NH_4)_2CO_3 =$$

Toluene sulphonic chloride

$$C_6H_4\begin{cases}CH_3\\SO_2.NH_2\end{cases} + NH_4Cl + H_2O + CO_2.$$

Toluene sulphonic amide

As the mixture is very liable to solidify on cooling, cold water is at once added to prevent this, and to dissolve out the ammonium chloride, the amide remaining in the solid state. The liquid is separated by centrifugating.

STEP VII.—The orthotoluene sulphonic amide is now oxidised, preferably by means of potassium permanganate. The result of this will be, precipitated manganese dioxide, free alkali and alkaline carbonate, and an alkaline orth sulphamido-benzoate. The alkaline liquid requires careful neutralisation during the oxidising process, and especially before evaporating, with a mineral acid, or else the sulphamido-benzoate formed would be again split up into orthosulphonic benzoate and free ammonia, thus:—

$$C_6H_4\begin{cases}CO.ONa\\SO_2.NH_2\end{cases} + NaOH = C_6H_4\begin{cases}CO.ONa\\SO_2.ONa\end{cases} + NH_3.$$

The oxidation process itself is thus represented:—

$$C_6H_4\begin{cases}CH_3\\SO_2.NH_2\end{cases} + 3O + NaOH =$$

$$C_6H_4\begin{cases}CO.ONa\\SO_2.NH_2\end{cases} + 2H_2O.$$

Sodium orthotoluene sulphamido-benzoate

By precipitation with dilute mineral acids, such as hydrochloric or sulphurous acids, the pure benzoyl sulphonic imide is at once precipitated:—

$$C_6H_4\begin{cases}CO.ONa\\SO_2.NH_2\end{cases} + HCl =$$

$$NaCl + H_2O + C_6H_4\begin{Bmatrix}CO\\SO_2\end{Bmatrix}NH.$$

"Saccharine," or benzoyl sulphonic imide

Saccharine possesses a far sweeter taste than cane sugar, and has a faint and delicate flavour of bitter almonds. It is said to be 220 times sweeter than cane sugar, and to possess considerable antiseptic properties. On this account, and because of its great sweetness, it is possible that it may be useful in producing fruit preserves or jams, consisting of almost the pure fruit alone; the small percentage of saccharine necessary for sweetening these preserves being probably sufficient to prevent mouldiness. Saccharine has been proved by Stutzer, of Bonn, to be quite uninjurious when administered in considerable doses to dogs, the equivalent as regards sweetness in sugar administered, being comparable to over a pound of sugar each day. Stutzer found, moreover, that saccharine does not nourish as sugar does, but that it passes off in the urine unchanged. It is proposed thus to use it for many medical purposes, where cane sugar is excluded from the diet of certain patients, as in cases of "diabetes mellitus," and in this respect it may prove a great boon to suffering humanity, although we must remember that, as certain of the aromatic compounds if administered for a length of time are known to exert a physiological effect, especially on the liver, it will be desirable to use caution in the regular use of saccharine until its harmless action on the human body has been ascertained beyond doubt.

Saccharine is with difficulty soluble in cold water, from hot aqueous solutions it is easily crystallised. Alcohol and ether easily dissolve it. Hence from a mixture of sugar and saccharine, ether would easily separate the saccharine by solution, leaving the sugar. It melts at about 200° C. with partial decomposition.

The taste is a very pure sweet one, and in comparison with cane sugar it may be said that the sensation of sweetness is much more rapidly communicated to the palate on contact with saccharine than on contact with sugar. The speaker expressed his thanks to the discoverer of saccharine, Dr. Fahlberg, of Leipzig, for a complete and interesting series of preparations illustrating the domestic and medicinal uses of this remarkable compound, and also to his friend Mr. Watson Smith for the kind aid afforded him in the experimental illustration of his discourse.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, May 20.—"On the Working of the Harmonic Analyser at the Meteorological Office." By Robert H. Scott, F.R.S., and Richard H. Curtis, F.R.Met.Soc.

On the 9th of May, 1878, Sir W. Thomson exhibited to the Society a model of an integrating machine, which consisted of a series of five of the disk, globe, and cylinder integrators, which had been devised two years earlier by his brother Prof. James Thomson, and a description of which will be found in the *Proceedings* of the Royal Society, vol. xxiv. p. 262. Sir W. Thomson's paper describing this model will be found in vol. xxvii. of the *Proceedings*, p. 371; and reference should be made to both these papers for an explanation of the principle of the machine. In the communication last named it is stated that the machine was about to be "handed over to the Meteorological Office, to be brought immediately into practical work."

The model was received at the Office in the course of the

month, and was at once set in action; the results of the preliminary trials when obtained being referred to a Committee consisting of the late Prof. H. J. S. Smith and Prof. Stokes, who, on July 5 following, submitted to the Meteorological Council a favourable report on the performance of the model.

The Council at once resolved to have a machine constructed, which should be specially adapted to the requirements of the work for which it was intended, viz. the analysis of photographic thermograms and barograms.

In preparing a working design for actual execution, it was found necessary to make several modifications in the details of the mechanical arrangements of Sir W. Thomson's original model, and these were mainly worked out by Prof. Stokes and Mr. de la Rue. The construction of the instrument was intrusted to Mr. Munro. It was considered sufficient to limit the action of the machine so as to extend only to the determination of the mean, and the coefficients as far as those of the third order, in the expression

$$E = a + a_1 \cos\theta + b_1 \sin\theta + a_2 \cos 2\theta + b_2 \sin 2\theta + a_3 \cos 3\theta + b_3 \sin 3\theta + \&c.,$$

and to obtain these it was necessary to have seven sets of spheres, disks, and cylinders.

A description of the machine, as actually constructed, together with engravings giving a general view of the machine, and illustrating some of its details, will be found in *Engineering* for December 17, 1880.

The machine was delivered at the Office in December 1879, and a lengthened series of trials was at once commenced, to determine its constants, and thoroughly test the accuracy of its working, for which purpose systems of straight lines and curves, of which the values were known, were first used. A few small unforeseen difficulties were early met with, necessitating slight modifications in some portions of the instrument.

The chief of these faults was a slight turning of the cylinders upon their axes, when the balls were moved to and fro along the disks, parallel to the axes of the cylinders. The movement was always in the same direction, namely, towards the disks, whether the ball was moved to the right or left. After the trial of many expedients the defect was finally, in great measure, overcome by attaching weights to the spindles of the cylinders. It however still exists in the machine to a slight extent, and its effect is to *decrease* the readings on the cylinders by a very small amount.

It was decided to employ the analyser, in the first instance, in the determination of temperature constants, and careful comparisons have been made of the results obtained by its means with those got by actual measurement of the photographs and numerical calculations, as will presently be mentioned, and the accordance is so very close as to prove that the machine may safely be trusted to effect reductions which could only otherwise be accomplished by the far more laborious process of measurement and calculation.

It will facilitate an apprehension of the method of using the machine to give a somewhat detailed account of the operations involved in the treatment of the curves, with an example of the manner in which the readings of the machine are recorded and dealt with.

The machine is furnished with three pairs of recording cylinders and disks, numbered consecutively 1 to 6, which give the coefficients for the first three pairs of terms of the expansion, and in addition a seventh cylinder and disk from which the mean is obtained. In the thermograms which supply continuous photographic records of the march of temperature, the trace for twenty-four hours covers a length of 8·75 inches, while a vertical height of about 0·7 inch[1] corresponds to a range of ten degrees in temperature; each thermograph sheet contains the record for forty-eight hours.

Conveniently placed in the machine is a cylinder or drum, the circumference of which is equal to the length of twenty-four hours upon the thermograms. Round this cylinder the thermograms are rolled, the fluctuations of temperature indicated by the curves being followed, as the cylinder revolves, by a combination of the movement of the cylinder with that of a pointer moving in a line parallel to its axis.

The handle by which the cylinder is turned gives motion at the same time to the seven disks of the machine, and the operator thus controls by his left hand both the speed with which the curves are paid through the machine and the consequent velocity of the angular motion of the disks, while, by a suitable contrivance, the movements of the pointer, governed by his right hand and following the curve, produce on the face of the disks corresponding movements to the right or left of the balls by which the motion of the disks is conveyed to the recording cylinders.

At the commencement of an operation all the cylinders are set to zero; the twelve months curves are then passed consecutively through the instrument; the first pair of cylinders, which gives the coefficients of the first order, and also the mean cylinder, 7, being read for each day, while cylinders 3 and 4, and 5 and 6, which give the coefficients of the second and third orders respectively, are only read for each five days and at the end of each calendar month. The numbers on the cylinders are, however, progressive, so that the increments upon them for any given period could very easily be obtained.

At present only the monthly increments of the readings have been dealt with, so as to obtain the coefficients of the mean daily variation for each month of the year. The process followed is, therefore, simply to divide the monthly increment by the number of days in the month, and then to multiply the quotient by a factor which is determined by the scale-value of the thermograms, and which will therefore be different for each observatory.

As an illustration, the case of Kew for July 1882 may be taken. The increments for the month obtained from the final readings of the cylinders are as follows:—

Cylinder	1.	2.	3.	4.	5.	6.	7.
Observed increment	+2·198	−2·671	−0·101	−0·198	−0·797	−0·564	+56·839
Divided by 31 (the number of days).........	+0·071	−0·086	−0·003	−0·006	−0·026	−0·018	+1·834
Factor	−53·52	+53·52	−26·76	−26·76	−17·84	−17·84	+6·69
Coefficient deduced.........	−3·80	−4·60	+0·08	+0·16	+0·46	+0·32	+12·27
Add constant......... ...							48·17
Mean temperature.........							60·44

After some trials with the curves for the year 1871, the year 1876 was taken up, inasmuch as for that year the records had been discussed by Mr. H. S. Eaton, F.R.Met.Soc., who had calculated the hourly means of the various meteorological elements for each month separately, and who kindly placed his results at the disposal of the Council.

The working of the machine was thus subjected to an exact test by comparing the results obtained by it with the coefficients in the harmonic series which were calculated from Mr. Eaton's means; and their trustworthy character, and the adequacy of these calculations to serve as a standard with which the coefficients obtained by means of the machine might be compared, was established by calculating them from the *odd* and *even* hours, quite independently, for all the seven observatories.

The outcome of this experiment was thoroughly satisfactory, and the entire series of results obtained both by calculation and from the machine was published as Appendix IV. to the Quarterly Weather Report for 1876, together with a Report prepared by Prof. Stokes, the concluding paragraphs of which may be quoted here, since they sum up in a few words the conclusions arrived at.

[1] This value varies slightly for each observatory.

"Disregarding now the systematic character of some of the errors, and treating them as purely casual, we get as the average difference between the constants as got by the machine and by calculation from the twenty-four hourly means $0^{\circ}\cdot065$. It may be noticed, however, that the numbers are unusually large (and at the same time very decidedly systematic) in the case of the second cylinder of the first order b_1, for which the average is as much as $0^{\circ}\cdot150$, the seventh of a degree.

"If b_1 be omitted, the average for the remaining cylinders of the machine is reduced to $0^{\circ}\cdot047$.

"We see, therefore, that, with the exception perhaps of b_1, the constants got by the machine for the mean of the days constituting the month are as accurate as those got by calculation, which requires considerably more time, inasmuch as the hourly lines have to be drawn on the photograms, then measured, then meaned, and the constants deduced from the means by a numerical process by no means very short."

The curves for the twelve years 1871 to 1882 inclusive have now been passed through the machine, and the results obtained have been carefully checked so far as the arithmetical work involved is concerned, upon a plan approved by the Council. No *direct* check, short of passing the curves a second time through the machine, can however at present be put on any portion of the results except as regards the means, which have been compared with the means calculated from the hourly readings obtained by measurement from the curves. The results of this work will be published in the Hourly Readings for 1883, but the general results may here be stated.

As a rule, the monthly means yielded by the harmonic analyser agree well within a tenth of a degree with those obtained by calculation from the hourly measurements of the curves; and although in some exceptional cases larger differences have been found, amounting in rare instances to as much as half a degree, it is probable that generally these are less due to defects in the working of the instrument than to other causes. In some cases large breaks in the curves, due to failure of photography, &c., were interpolated when the curves were passed through the machine, but not when the means were worked out from measurements of the curves. Some differences rather larger than usual, and confined chiefly to the earliest years dealt with, have been ascertained to have arisen from the circumstance that when the curves were first measured, to obtain hourly values, the method of making the measurements was not the same as that found by subsequent experience to be the preferable; and also that in some cases the scale-values first used were less accurately determined than has since been found possible.

In both these respects the two methods were on a par in the later years dealt with, and therefore the fairest comparison is to be had with their means.

For 1880, the average difference of the monthly mean for all the seven observatories is $0^{\circ}\cdot09$; for 1881 it is $0^{\circ}\cdot05$; and for 1882 $0^{\circ}\cdot06$; and in these three years a difference of $0^{\circ}\cdot3$ between the analyser and calculated means occurred but once, and of $0^{\circ}\cdot2$ but five times.

What has been said is sufficient to show that the instrument is completely applicable to the analysis of thermograms.

It has also been employed on the discussion of barograms, and the curves for the years 1871, 1872, and 1876 have been passed through the machine.

The year 1876 was selected owing to the existing facilities for comparing the resulting figures with those obtained by calculation from Mr. Eaton's means, and the result in this case was equally satisfactory with that for temperature already mentioned.

May 27.—"Family Likeness in Eye-Colour." By Francis Galton, F.R.S.

This inquiry proved that certain laws previously shown by the author to govern the hereditary transmission of stature also governed that of eye-colour: namely, that the average ancestral contributions towards the heritage of any peculiarity in a child are from each parent $\frac{1}{4}$, from each grandparent $\frac{1}{16}$, and so on; also that each parent and each child of any person will on the average possess $\frac{1}{3}$ of that person's peculiarity. The eye-colours were grouped into light, hazel (or dark gray), and dark; then it was shown that $\frac{2}{3}$ of the hazel were fundamentally light, and $\frac{1}{3}$ of them were dark, and they were statistically allotted between light and dark in that proportion. The desired test of the truth of the laws in question was thus reduced to a comparison between the calculated and observed proportion of light- and dark-eyed children born of ancestry whose eye-colours presented various combinations of light, hazel, and dark. The inquiry was confined to children of whom the eye-colours of both parents and of all four grandparents were known. There are six possible combinations of the three eye-colours in the parents, and fifteen in the grandparents, making a total of ninety possible classes, but of these one-half were wholly unrepresented in the returns, and many others were too scantily represented to be of use. The remainder were discussed in six different ways: that is to say, in two groups, *a* and *b*, and each group by three methods. In *a* the families were classified and grouped according to their several ancestral combinations of eye-colour, but only those groups that consisted of twenty or more children were used; there were 16 of these groups and 827 children. In *b* the families were treated separately, but only large families were taken, viz. those that consisted of at least six children: they were 78 in number. In both *a* and *b* separate calculations were made on the suppositions (1) that the parental eye-colours were alone known; (2) that the grandparental were alone known; (3) that the parental and the grandparental were alone known. The conformity between the calculated and the observed numbers throughout every one of the six sets of calculations was remarkably close, and the calculated results obtained by the method (3) were the best.

"Notes on Alteration induced by Heat in Certain Vitreous Rocks, based on the Experiments of Douglas Herman, F.I.C., F.C.S., and G. F. Rodwell, late Science Master in Marlborough College." By Frank Rutley, F.G.S., Lecturer on Mineralogy in the Royal School of Mines. Communicated by Prof. T. G. Bonney, B.Sc., F.R.S.

In this paper an endeavour has been made to ascertain the nature of the changes which are induced in a few typical vitreous rocks by the action of heat only. The specimens experimented upon were—

(1) The pitchstone of Corriegills, Arran.
(2) Black obsidian from Ascension.
(3) Black obsidian from the Yellowstone District, U.S.A.
(4) Glassy basalt lava of Kilauea, Hawaii.
(5) Basalt of the Giant's Causeway, Antrim.

The Arran pitchstone was heated for 216 hours at a temperature ranging from 500° to about 1100° C. The clear, greenish belonites of hornblende, so plentiful in the unaltered rock, were found to have turned to a deep rusty brown through peroxidation of the protoxide of iron which was present in the hornblende. The dusty matter mixed with clear spiculæ of hornblende, which occurred between the belonites and shaded gradually off into the clear glass which immediately surrounded the belonites in the normal state of the rock, has segregated to some extent, a sharp line of demarcation now existing between the dusty matter and the areas of clear glass, while the spiculæ of hornblende have somewhat increased in size if not in number. No actual devitrification of the glass has resulted from the heating.

The obsidian from Ascension showed only a banded structure coupled with streams of colourless microliths and a few felspar crystals when a section of the unaltered rock was examined microscopically. Two specimens of this rock were artificially heated, the first for the same period and at the same temperature as the Arran pitchstone, while the second was kept for 701 hours at a temperature ranging from 850° to 1100° C.

In the first specimen the banded structure disappeared entirely, or almost entirely, but numerous microliths are present in the altered rock, in which the most remarkable change consists in the development of an excessively vesicular structure.

In the second specimen a vesicular structure is also developed, an outer crust consisting of a very thin layer of clear brownish glass, followed by a nearly opaque layer composed of greenish-brown microliths, which shades off into a colourless glass containing similar microliths, which are probably some form of amphibole or pyroxene. The remainder of the specimen has been completely devitrified.

The Yellowstone obsidian in its normal state shows little else but trichites and globulites when examined under a high power.

Two specimens of this rock were heated: the first at from 500° to 1100° C. for a period of 216 hours, the second from 850° to 1100° C. for 701 hours. In the first case a remarkably vesicular structure has been developed; the trichites have entirely disappeared, and small granules and crystals of magnetite have been formed. In the second specimen the changes are very peculiar. The fragment retained its original form, but the surface showed minute blisters or elevations, which, when when cracked open, revealed a cavernous structure produced by

the coalescence of vesicles averaging from ¼ to ½ inch in diameter. These cavities were often lined with a white crystalline crust, and generally contained white crystalline pellets, each about one-third the size of the cavity in which it occurred. Minute crystals of specular iron were detected upon the surfaces of these pellets. The glassy part of the rock, which still remains clear, contains trichites and globulites similar to those in the unaltered obsidian, but they are more numerous in the artificially-altered rock.

The vesicular glassy basalt lava of Kilauea, when examined under the microscope, is seen to contain crystals of olivine and minute crystallites which have not hitherto been referred to any particular mineral species. A specimen of this lava, kept for 960 hours at a temperature ranging from 750° to 1200° C., shows that the olivine crystals have undergone no appreciable alteration, but the glass itself has become perfectly opaque and black, owing to the separation of magnetite.

The specimens of basalt from the Giant's Causeway were fused in Stourbridge crucibles in a gas furnace. One, which was cooled rapidly, appears under the microscope as a clear glass containing vesicles; another, cooled slowly, is black and opaque, except in certain spots where a prismatic structure is visible, the marginal portions of the prisms having a radiating crystalline or fibrous character.

In another case some of the powdered basalt was again fused, and a fragment of cold basalt was placed on the surface and allowed to sink into the molten mass. The result was a glass, which, under the microscope, appears perfectly clear except in the immediate vicinity of the immersed fragment, which is surrounded by an opaque black border containing divergent groups of colourless transparent or translucent crystals. The black border, where it joins the clear glass, is sharply defined, and its opacity and blackness must be regarded as due to a separation of magnetite, as in the case of the altered Kilauea lava.

The first series of experiments were made by Mr. Herman. The specimens from the Giant's Causeway were experimented upon by Mr. Rodwell.

Zoological Society, June 1.—Dr. A. Günther, F.R.S., Vice-President, in the chair.—Dr. A. Günther, F.R.S., exhibited and made remarks on a specimen of a small fish of the genus *Fierasfer* embedded in a pearl oyster.—The Secretary made some remarks on the most interesting objects he had observed during a recent visit to the Zoological Gardens of Rotterdam, Amsterdam, Cologne, Antwerp, and Ghent.—A letter was read from Mr. J. M. Cornely, of Tours, C.M.Z.S., stating that his pair of Michie's Deer had bred in his park, and that a young one had been born on May 15.—Mr. Beddard read notes on the convoluted trachea of a Curassow (*Nothocrax urumutum*), and on the form of the syrinx in certain Storks.—Mr. W. F. Kirby read a paper containing an account of a small collection of Dragon-flies which had been formed by Major J. W. Yerbury at Murree and Campbellpore, N.W. India. The collection contained examples of about twenty species.

Physical Society, May 22.—Prof. Balfour Stewart, President, in the chair.—Messrs. C. A. Bell, W. C. Johnson, and James Swinburne were elected Members of the Society.—The following communications were read:—On the sympathetic vibrations of jets, by Mr. Chichester A. Bell. It has been assumed hitherto that a gaseous or liquid jet vibrates under the influence of a limited range of tones only; effective tones being those which do not differ greatly in pitch from the normal or proper tone of the jet, discovered by Savart and Sondhauss. The author has found, however, that, when the pressure under which a jet escapes is not too great, the latter is affected by all tones lower than the normal, as well as by some above it. Changes may be excited in a jet of either kind by vibratory motions of the jet orifice, or of the fluid behind or external to the orifice. These changes take the form of slight swellings and contractions, which become more pronounced as the fluid travels away from the orifice, and finally cause the jet to break or become discontinuous at a distance which depends upon the intensity of the initial disturbances. At any point within the continuous portion of the jet the successive swellings and expansions represent both the form and the relative intensities of vibrations impressed upon the orifice, and the jet is therefore capable of reproducing very complex sounds, such as those of speech and music. A vibrating jet of air does not, however, emit sound when it plays into free air, or into the wide end of a tube communicating with the ear; but when it plays against a very *small* orifice in the end of a hearing tube, loud sounds may result. This reproduction is most intense when the hearing orifice is placed in the axis of the jet, just within the breaking point, but becomes gradually feebler as the hearing orifice is moved towards the jet orifice or out of the line of its axis. Beyond the breaking point the sounds from the jet at first become confused, and finally are lost. A jet of gas, like a liquid jet, only vibrates so as to produce its normal tone when it strikes upon some obstacle which serves to diffuse the disturbances due to impact, or throw them back upon the orifice. The vibrations of an air jet are also loudly reproduced as sound when it is directed against a small flame below the apex of the blue zone. Liquid jets are but slightly sensitive to aërial sound-impulses, but become highly sensitive when the jet tube is rigidly attached to a sound-board. The vibrations of a jet so mounted are best perceived as sound when the stream strikes upon a rubber membrane tied over the end of a narrow tube which communicates with the ear. For accurate reproduction of speech and sounds in general the jets should be at such a pressure as to respond visibly to a note of about 4000 vibrations per second; and the membrane should be at such a distance from the orifice that the jet never breaks or becomes discontinuous above its surface. The vibrations of very fine jets of any conducting liquid become loudly audible when a portion of the jet, or the "nappe" formed when it strikes upon a flat surface, is included in circuit with a battery and a telephone. This may be accomplished by letting the jet impinge on the end of an ebonite rod, through the centre of which passes a platinum wire; the upper end of the rod is surrounded by a short tube or ring of platinum, the upper margin of which forms a continuous, slightly convex surface with the exposed end of the central wire and the ebonite. The wire and ring form the terminals of the circuit which is completed through the "nappe." Distilled water containing 1/300 of its volume of pure sulphuric acid is recommended as the jet liquid. The author advances a new theory to account for the growth of the vibratory changes in liquid and gaseous jets.—On some thermo-dynamical relations, part 5, by Prof. W. Ramsay and Dr. S. Young. In parts 1 and 2 of this series of papers it was shown that the ratio of the absolute temperatures of any two bodies corresponding to a given vapour-pressure bears a simple relation to the ratio at any other pressure, which may be expressed by the equation $R' = R + c(t' - t)$; where R' and R are the two ratios, c is a constant, and t' and t are the temperatures of one of the two bodies. The determination by Schumann (*Pogg. Ann.*, N.F. 12, 46) of the vapours of methyl-formate and twenty-seven homologous ethers made it possible to compare the vapour-pressures of a large number of bodies belonging to the same class. It was found that when the ethers were compared with ethyl acetate, which was taken as the standard, in every case $c = 0$, and therefore $R' = R$. The temperatures corresponding to the three pressures 260, 760, and 1300 mm. are given by Schumann. Taking the mean value of R for those pressures as correct, and recalculating the temperatures, the greatest difference between the found and recalculated temperatures is 0°·7 C. The vapour-pressures of water or any one of the ethers being accurately known, it is sufficient to determine the boiling-point of any ether belonging to this class, in order to construct its vapour-pressure curve. The absolute temperatures corresponding to the pressures 200 and 1300 mm. for any ether are $\cdot 89795t$ and $1\cdot 0488t$, where t is the boiling-point at normal pressure in absolute temperature.—A grid-iron slide-rule by Mr. Stanley, designed by Mr. Thacher, was explained by Mr. C. V. Boys. It was equivalent to a slide 60 feet long, and performed multiplication and division with an error not exceeding the 1/40,000 part.—Specimens of safety explosives and their results in shattering blocks of lead were exhibited by H. Sprengel.

Geological Society, May 12.—Prof. J. W. Judd, F.R.S., President, in the chair.—Matthew Blair was elected a Fellow, and Prof. H. Rosenbusch, of Heidelberg, a Foreign Correspondent of the Society.—The following communications were read:—On the maxilla of Iguanodon, by J. W. Hulke, F.R.S.—Notes on the distribution of the Ostracoda of the Carboniferous formations of the British Isles, by Prof. T. Rupert Jones, F.R.S., and J. W. Kirkby. Although all the Ostracoda of the Carboniferous formations are not yet described, there are 170 species and notable varieties known, belonging to thirty-three genera of nine families. About twenty-five of these species, not yet described, but determined by the authors, are introduced into

their lists as giving a fuller idea of the value of this manifold Crustacean group. In the first place they referred to the classification of the Carboniferous strata in Scotland and in England, according to the local differences, taking in succession "Scotland West," "Scotland East," "England North, with the Isle of Man," "England Central and South, with South Wales," as the several districts from which they have obtained good groups of Ostracoda from different members of the Carboniferous series. In Fife the lowest local Carboniferous strata contain *Beyrichia subarcuata;* higher up come in *Carbonia fabulina, C. Rankiniana, Bairdia nitida,* and *Leperditia Okeni;* the last, accompanied by other species, occurs throughout this lowest series, in which the record is more complete than in Midlothian and Linlithgowshire, where the same species also occur. In Dumfriesshire and Ayrshire *L. Okeni* and *L. subrecta* have been found in beds even lower than the above-mentioned, and are therefore probably the oldest Carboniferous Ostracoda; other species accompany them higher up, and in Roxburghshire some localities of the Carboniferous Sandstone series are very rich in species. The Carboniferous Limestone series of South-West Scotland has been highly productive of Ostracoda, particularly the shales of the lower beds; thirty-six species are common or characteristic. The middle or coal-bearing portion has yielded but few, chiefly *L. Youngiana*, one Beyrichia, *C. fabulina,* and *C. Rankiniana.* The Upper Limestone group contains many recurrents from below and a few others, including *Youngia rectidorsalis* (MS.). The Millstone Grit equivalents have no Ostracoda, but the overlying Coal-measures are rich in *Carboniæ*, with a few others, such as *Cypridina radiata.* A great variety of genera and species come from beds at or near the base of the Scar Limestone and its equivalents in North Lancashire, Westmoreland, Cumberland, and Northumberland. The calcareous shales of the Yoredale series have several interesting forms, including *Placentura concinna* (MS.); none from the Millstone Grit. The Lower Coal-measures give *Beyrichia arcuata* and *Carbonia*, sp. The middle beds have *B. arcuata* and *Carbonia fabulina*, common; rarer, *C. Rankiniana, C. secans, C. scalpellus, C. Wardiana* (MS.), and *Philomedes elongata.* In the Upper Coal-measures *B. subarcuata* reappears; and in the *Spirorbis*-limestone *Leperditia inflata* is the latest Carboniferous Ostracod in England. In Northamptonshire the deep Gayton boring (at 730 feet) has given *Kirkbya variabilis, K. plicata, Bythocypris sublunata, Macrocypris Jonesiana, Cytherella extuberata,* and *C. attenuata*, all but one belonging to the Lower Carboniferous series. In Salop, South Wales, and Somerset the Carboniferous Limestone has yielded several good species of *Leperditia, Kirkbya, Moorea, Bythocypris, Bairdia,* &c. *Carbonia Agnes* and *C. Evelinæ* belong to the South Welsh Coal-measures. The distribution of the Carboniferous Ostracoda in Ireland requires further work; but the Lower Carboniferous Shales and the Mountain Limestone near Cork and elsewhere are very rich, as are also some parts of the latter in the Isle of Man. The Ostracoda of the Permian Formation were then treated of in relation to their Carboniferous allies, and the range of the British Carboniferous Ostracods in Europe and North America was noticed in some detail. The results of the examination were shown in two extensive tables.—Note on some Vertebrata of the Red Crag, by R. Lydekker, F.G.S. This communication contained briefly the results of a re-examination of the specimens from the bone-bed of the Red Crag in the British and Ipswich Museums, a series of casts from the latter having been added to the former. The forms noticed were *Hyæna striata*, with which *H. antiqua* and *H. arvernensis* were considered probably identical, *Mastodon*, of which the author thought three species—*M. arvernensis, M. longirostris,* and *M. borsoni* were represented; *Sus*, of which two forms, the larger probably *S. erymanthius* or *S. antiquus*, the smaller *S. palæochœrus*, had been detected; a Tapir, which was probably *Tapirus arvernensis* or *T. elegans* rather than *T. priscus; Hipparion gracile;* a *Rhinoceros* referable to the hornless *R. incisivus* rather than to *R. schleirmacheri*, though the latter probably also occurred; and a species of Albatross (*Diomedea*) represented by a right tarso-metatarsus, and the associated proximal phalangeal bone of the fourth digit.—The Pleistocene succession in the Trent Basin, by R. M. Deeley, F.G.S. The beds of the lowest division were distinguished from those of the middle and upper by the absence of Cretaceous rock-debris. Older Pleistocene: Early Pennine Boulder-clay, Quartzose Sand, Middle Pennine Boulder-clay; Middle Pleistocene: Melton Sand, Great Chalky Boulder-clay, Chalky Sand and Gravel; Newer Pleistocene: Interglacial River-alluvium, Later Pennine Boulder-clay. Each of the separate stages was then described separately, with details of exposures and sections throughout the area.—On the existence of a submarine Triassic outlier in the English Channel off the Lizard, by R. N. Worth, F.G.S.

Anthropological Institute, May 25.—Francis Galton, F.R.S., President, in the chair.—Mr. Reginald Stuart Poole read a paper on the ancient Egyptian classification of the races of man. This was defined by the famous subject of the four races in the tombs of the kings at Thebes (B.C. 1400–1200). The types were (1) Egyptian, red; (2) Shemite, yellow; (3) Libyan, white; (4) Negro, black. By comparison with monuments of the same period and of a somewhat earlier date, the first race, clearly an intermediate type, was seen to comprehend the Phœnicians, the Egyptians, and the people of Arabia Felix with the opposite coast. The Libyan race included an aquiline type, with marked supra-orbital ridges and receding foreheads, as well as a straight-nosed type. These two types inhabited the south coast of the Mediterranean, and some of the islands. The Negro race included the Negro and Nubian types. The Hittites and Hyksos, or shepherds, were as yet unclassed. Prof. Flower pointed out the resemblance of the aquiline Libyan type to that of the Neanderthal crania, and the oldest European type, and saw in the Hyksos head distinctly Mongolian characters. These two points are of the highest consequence in historical anthropology.—Mr. C. W. Rosset exhibited a large collection of photographs and other objects of ethnological interest from the Maldive Islands and Ceylon.

PARIS

Academy of Sciences, May 31.—M. Jurien de la Gravière, President, in the chair.—Observations of the small planets made with the large meridian instrument at the Paris Observatory during the first quarter of the year 1886, by M. Mouchez.—Note on a new general method of determining directly the absolute value of refraction at all degrees of altitude, by M. Lœwy. This is a further development and more general application of the author's recent communication on the means of determining some absolute values of refraction with a sufficient degree of accuracy.—Researches on the densities of liquefied gases and of their saturated vapours, by MM. L. Cailletet and Mathias. In this memoir the authors' studies are limited to the protoxide of nitrogen, ethylene, and carbonic acid. It is shown that at the critical point the density of the fluid is equal to that of its vapour, whence a practical means of determining graphically the density at the critical point when the critical temperature is known. It is also shown that the expansion of the liquefied gas is greater than that of the gas itself. The methods here described are applicable to all gases whose critical point is higher than the freezing-point of mercury.—On MM. Albert A. Michelson and Edward W. Morley's recent experiments to ascertain the influence of motion of the medium on the velocity of light (*American Journal of Science*, May 1886), by M. A. Cornu. The author briefly describes the American physicists' experiments, which show that the result announced by Fizeau in 1851 is essentially correct, and that the luminiferous ether is entirely unaffected by the motion of the matter which it permeates. At the conclusion of the paper M. Fizeau took occasion to remark that he had never ceased to prosecute his studies on the nature and properties of the ether, and hoped soon to announce the existence of a peculiar variation in the magnetic force of magnets apparently in relation with the direction of the earth's motion through space, and calculated to throw great light on the immobility of the ether and its relations to ponderable matter.—On an arc tangent to the solar halo of 46°, observed on May 30, by M. A. Cornu. Of the numerous halos observed during last month this is described as the most remarkable. It was visible towards 5 p.m. under the form of an extremely vivid iridescent arc concentric with the zenith at a distance of 15° to 20° in a circular sphere of from 60° to 80°. The author considers that from the systematic observation of these phenomena some valuable data might be obtained regarding the condition and movements of the upper atmospheric currents, which would be useful in weather forecasting.—On the heats of combustion and of formation of the solid carburets of hydrogen, by MM. Berthelot and Vieille. The method announced by the authors two years ago for measuring the heat of combustion of the fixed or but slightly volatile organic compounds is here applied to the study of naphthaline, acenaphthene, anthracene, phenanthrene, dibenzyl, and some other

carburets chosen on purpose with a view to determining certain general relations.—On the ammonia present in the ground: a reply to MM. Berthelot and André, by M. Th. Schlœsing. The points in dispute are re-stated, and the author deals fully with the chief objections urged by MM. Berthelot and André against his view that generally speaking the ammonia passes from the atmosphere to the earth.—Note accompanying M. Silvestri's report on the eruption of Mount Etna on May 18 and 19, by M. Daubrée. It is noticed that the present lava-stream, like that of 1883, flows from the crevasse which was opened on the flank of the volcano in the direction from north-east to south-west in the year 1875. But it rises at an elevation of about 1400 metres some 7 kilometres above the town of Nicolosi, which has thus so far escaped destruction.—On the influence of magnesia on Portland cements, by M. G. Lechartier. The author's extensive researches amongst public buildings and structures of all sorts fully confirm the conclusion already arrived at by Rivot regarding the destructive effects of the magnesia present in these cements. The more they are exposed to the direct action of water, the more rapid is the process of decay.—Observations of the new comet Brooks III., made at the Observatory of Nice with the Gautier equatorial, by M. Charlois.—Note on the theoretic calculation of the composition of vapours, their coefficients of expansion, and vaporising heats, by M. M. Langlois. The formulas which in the author's theory give the specific heats of the gases or vapours are as under:—

$$\begin{array}{llll} & \text{Atm.} & & \\ \text{Molecules at} & 1 & \ldots\ \ldots & C = \frac{2}{3}\dfrac{V\pi Pg}{9}\alpha = \frac{2}{3}A\alpha \\ \quad ,, & 2 & \ldots\ \ldots & C = A\alpha \\ \quad ,, & 3 & \ldots\ \ldots & C = \frac{4}{3}A\alpha \\ \quad ,, & 4 & \ldots\ \ldots & C = \frac{5}{3}A\alpha \end{array}$$

where α is the coefficient of expansion of the vapour, V the volume occupied by 1 kilogramme of this vapour under the pressure P. The complete theory will be explained at the next Congress of the French Association at Nancy.—On the diffusion of heat and physical isomorphism, by M. L. Godard. The property of being athermochroic, hitherto supposed to be peculiar to pure common salt and sylvine (natural chloride of potassium), is shown to be also characteristic of the isomorphous and anhydrous chlorides, bromides, and iodides. These substances have the same chemical formula and crystallise in the same system, and thus is once more confirmed the analogy presented by the physical properties of isomorphous bodies.—Law of the product corresponding to the maximum of useful work in an electric distribution, by M. Vaschy. It is shown that Jacobi's law (product $= \frac{1}{2}$) is inapplicable to the case of a dynamo-generator whose electromotor force is a function of the current traversing it.—On the cyclonic whirlwind of May 12: influence of the Guadarama mountain-range on its progress through the Iberian peninsula (second note), by M. A. F. Nogues. The fresh impulse given to this Atlantic cyclone by contact with the cold dry upland currents in the neighbourhood of Madrid show that under special conditions the central Spanish plateau may be compared to certain tropical regions, producing in Spain meteoric phenomena analogous to those of the torrid zone.—On the heats of combustion of the fatty acids and of some fatty substances derived from them, by M. W. Louguinine. Completing his previous studies on the heat of combustion of the fatty acids and their derivatives, the author here treats of caprylic, nonylic, lauric, myristic, and palmitic acids, and of the trilaurine and trimyristine glycerines.—On the dissociation of the carbonate of lime, by M. H. Le Chatelier.—On a new gaseous body, the oxyfluoride of phosphorus, with the formula $PhFl_3O_2$, by M. H. Moissan.—On the direct chloridation of methylbenzoyl, by M. H. Gautier.—Action of oxygenated water on benzoic acid in the presence of sulphuric acid, by M. Hanriot. Having previously shown that oxygenated water reacts on the benzenic hydrocarburets in sulphuric solution, transforming them to phenols and diphenols, the author here extends this reaction to the aromatic acids, and especially to benzoic acid.—On jaborine, by MM. Hardy and Calmels.—Absorption of the bicarbonates of potassa and lime by the roots of beetroot during the first year's growth, and their transformation to organic acids in combination with the potassa and lime diffused throughout the different parts of the plant during vegetation, by M. H. Leplay.—On the superficial measurement of the underground parts of plants, by M. Aimé Girard. A method is proposed by which the superficial development of vegetable roots may be approximately determined within about $\frac{1}{100}$ above or below the reality.—Fresh observations on the Jurassic bilobites, by M. Stan. Meunier. Several new forms of these curious fossil vestiges are described, tending more and more to show that they are of organic origin, and not merely animal footprints.—On the existence of the Lower Eocene formation in the Chalosse district, and on the position of the Bos d'Arros strata, by MM. Jacquot and Munier-Chalmas.

BOOKS AND PAMPHLETS RECEIVED

"Report of the Second Hudson's Bay Expedition, 1885."—"Charts showing the Ocean, Monthly and Annual Temperatures of Hudson's Bay Region and Eastern Canada, September 1884 to October 1885," by A. R. Gordon.—"Algebraical Exercises and Examination Papers," by H. S. Hall and S. R. Knight (Macmillan).—"Annalen des k.k. Naturhistorischen Hofmuseums," Band i., No. 2 (Hölder, Wien).—"Indice Alfabético de la Encyclopedia Popular Ilustrada de Ciencias y Artes," by F. Gillman (Gras, Madrid).—"Embryologische Studien an Medusen, Atlas," by E. Metschnikoff (Hölder, Wien).—"Report of the Metropolitan Board of Works, 1885."—"Electric Transmission of Energy," by C. Kapp (Whittaker and Co.).—"Physiology of Plants," by S. H. Vines (Cambridge University Press).—"A West Indian Sanitorium and a Guide to Barbadoes," by Rev. J. H. Sutton Moxly (S. Low).—"A Year in Brazil," by H. C. Dent (K. Paul).—"A Year with the Birds" (Blackwell, Oxford).—"Microbes, Ferments, and Moulds," by E. L. Trouessart (K. Paul).—"Catalogue of the Birds in the British Museum," vol. xi.—"Catalogue of the Fossil Mammalia in the British Museum," Part 3, by R. Lydekker.—"A Book of Duck Decoys," by Sir R. Payne-Gallwey (Van Voorst).—"Report of Experiments in the Manufacture of Sugar at Magnolia Station, Lawrence, La., Season of 1885-86," by G. J. Spencer (Washington).—"Principles and Methods of Soil Analysis," by E. Richards (Washington).—"Methods and Machinery for the Application of Diffusion to the Extraction of Sugar from Sugar-Cane and Sorghum," by H. W. Wiley (Washington).—"Proceedings of the Windsor and Eton Scientific Society, 1885" (Oxley, Windsor).—"Hydrophobia, M. Pasteur and His Methods," by Dr. T. M. Dolan (H. K. Lewis).

CONTENTS

PAGE

The 43-Ton Gun Explosion 117
Geology of Turkestan 117
The Naturalist's Diary. By Prof. John Wrightson 119
Our Book Shelf :—
Cambridge's "Scientific Results of the Second Yarkand Mission" 120
Letters to the Editor :—
The Thomson Effect.—**Prof. P. G. Tait** 120
Power in Laboratories.—**David P. Todd.** (*Illustrated*) 121
Scientific Nomenclature.—**G. Griffith** 122
Neæra.—**Wm. H. Dall** 122
"Plants and their Defences."—**Dr. E. Huth** . . . 122
A Remarkable Hailstorm.—**Dr. A. Ernst** 122
Visitation of the Royal Observatory 122
The Past Winter 124
The Astronomical Day 125
Facilities for Botanical Research. By Prof. F. O. Bower 127
Notes 129
Our Astronomical Column :—
Comet Brooks II. 131
Comet Brooks III. 131
Spectroscopic Determination of the Motion of the Solar System in Space 131
Publication of the Zone-Observations of the *Astronomische Gesellschaft* 131
The Madras Observatory 131
Astronomical Phenomena for the Week 1886 June 13-19 131
Biological Notes :—
Development of Ophiopholis and Echinarachnius . . 132
The Leeches of Japan 132
New Element of the Blood and its Relation to Coagulation 132
On Recent Progress in the Coal-Tar Industry, II. By Prof. Sir Henry E. Roscoe, M.P., F.R.S. . . 133
Societies and Academies 135
Books and Pamphlets Received 140